Early E. C.: / 1
Total HW Points Unit 12: / 32
Total Lab Points Unit 12: / 20
Unit 11 Apps.: / 5
Late, Incomplete, No Work, No Units Fee? Y / N

Unit 12 – Mechanical Waves and Sound

Essential Fundamentals of Mechanical Waves and Sound

1. Frequency of a sound or light wave is constant as it enters a new medium.

Add more here!

Equation Sandbox

In Unit 12, some of the following equations will be used. Practice isolating variables to prepare for it.

Possible 12.1 Pts: 5
Late, Incomplete, No Work, No Units Fee: -1 -2 -3
Final Score: / 5

12.1 Problems – Mechanical Wave Properties
Section 13.3 – 13.4 of your textbook.

1. A sound wave has a speed of 340 m/s in air. If this wave produces a tone with a frequency of 1000. Hz, what is its wavelength?

2. A surfer trying to catch a massive wave estimates the distance between two incoming wave crests is about 10.5 m, and that the arrival time between waves is 12.8 s. What is the approximate speed of the waves?

3. The range of sound frequencies audible to the human ear extends from about 20 Hz to 20 kHz. If the speed of sound in air is 345 m/s, what are the wavelength limits of this audible range?

4. What type(s) of wave(s), transverse or longitudinal, will propagate through (a) solids, (b) liquids, and (c) gases? How do transverse and longitudinal wave differ?

5. Standing on a hill and looking at a tall wheat field, you see a beautiful wave traveling across the field every time a breeze blows. What type of wave is this?

Possible 12.2 Pts: 6
Late, Incomplete, No Work, No Units Fee: -1 -2 -3
Final Score: / 6

12.2 Problems – Standing Waves & Resonance
Section 13.5 of your textbook.

1. If the frequency of the third harmonic of a vibrating string is 600 Hz, what is its fundamental frequency?

The fundamental frequency of a stretched string is 150 kHz. What are the frequencies of the:

2. Second harmonic?

3. Third harmonic?

A piece of steel string is under tension. Answer the following three questions, knowing this.

4. If the tension doubles, the transverse wave speed (1) doubles, (2) halves, (3) increases by a factor of $\sqrt{2}$, (4) decreases by a factor of $\sqrt{2}$. Why?

5. If the linear mass density of a 10.0-m length of string is 0.125 kg/m and it is under a tension of 9.00 N, what is the transverse wave speed in the string?

6. What is the string's fundamental frequency?

Possible 12.3 Pts: 5
Late, Incomplete, No Work, No Units Fee: -1 -2 -3
Final Score: / 5

12.3 Problems – Sound Waves
14.1 – 14.2 of your textbook.

1. What are the speeds of sound in air at:
    a. 10.0 °C

    b. 20.0 °C?

2. Sonar is used to map the ocean floor. If an ultrasonic signal is received 3.25 s after it is emitted, how deep is the ocean floor at that location? Use your resources in the back of the Booklet.

3. What temperature change from 0 °C would increase the speed of sound in air by 1.0%?

4. Particles approximately 3.0 E -2 cm in diameter are to be scrubbed loose from machine parts in an aqueous ultrasonic cleaning bath. Above what frequency should the bath be operated to produce wavelengths of this size and smaller?

Possible 12.4 Pts: 6
Late, Incomplete, No Work, No Units Fee: -1 -2 -3
Final Score: / 6

12.4 Problems – Sound Intensity
14.3 of your textbook.

1. Calculate the intensity generated by a 1.0-W point source of sound at a location A. 3.0 m and B. 6.0 m from it.

2. If the distance from a point sound source triples, the sound intensity will be (1) 3, (2) 1/3, (3) 9, (4) 1/9 times the original value. Why?

3. By how much must the distance from a point source be increased to reduce the sound intensity by half?

4. Find the intensity levels in decibels for sounds with intensities of (a) 1.0 E -1 W/m^2, (b) 1.0 E -5 W/m^2, and (c) 1.0 E -14 W/m^2.

5. At Cape Canaveral, on blastoff a rocket produces an intensity level of 160 dB as measured 10. m from the rocket. What would be the intensity level at 100 m away? Assume no energy is lost due to reflections etc.

6. What is the intensity level of a 23-dB sound after being amplified ten thousand times?

Possible 12.5 Pts: 5
Late, Incomplete, No Work, No Units Fee: -1 -2 -3
Final Score: / 5

12.5 – Sound Phenomena, Doppler Effect

Section 14.4 - .5 of your textbook.

1. A violinist and a pianist simultaneously sound notes with frequencies of 436 Hz and 440 Hz, respectively. What beat frequency will the musicians hear?

A violinist tuning her instrument to a piano note of 264 Hz detects three beats per second.

2. Which of the following options is correct? The frequency of the violin could be (1) less than 264 Hz, (2) equal to 264 Hz, or (3) greater than 264 Hz, (4) both (1) and (3). Explain why.

3. What are the possible frequencies of the violin tone in the previous problem?

4. What is the frequency heard by a person driving 60 km/h directly toward a factory whistle (f = 800 Hz) if the air temperature is 0°C?

5. Two identical strings on different cellos are tuned to the 440.0 Hz A-note. The peg holding one of the strings slips, so its tension is decreased by 1.5%. What is the beat frequency heard when the strings are then played together?

Possible 12.6 Pts: 5
Late, Incomplete, No Work, No Units Fee: -1 -2 -3
Final Score: / 5

12.6– Instruments & Sound Characteristics

Section 14.6 of your textbook.

The first three natural frequencies of an organ pipe are 126 Hz, 378 Hz, and 630 Hz.

1. Is the pipe open or closed? Explain your answer.

2. For the previous problem, taking the speed of sound in air to be 340 m/s, find the length of the pipe.

3. A closed organ pipe has a fundamental frequency of 528 Hz (A C note) at 20°C. What is the fundamental frequency of the pipe at 0 °C?

4. An organ pipe that is closed at one end has a length of 0.80 m. At 20.0 °C, what is the distance between a node and an adjacent antinode for the second harmonic?

5. Why does it sound particularly quiet after a snowfall?

AP Physics 1	Unit 12.1 Lab - Vibrating Strings	
Reminder: Update Table of Contents		Correction Credit: Half

Overview:

Strings under tension vibrate when plucked. The frequency of a vibrating string depends on its tension, length, and linear mass density. In this lab, you will calculate and measure the first - third harmonics of a string under tension.

Vibrating String Lab (12.1) Guide		
Contents, Title/Date, Synopsis, Purposes		/ 1
Mission 1: Data Table	String Length	/ 1
	Computed Frequency - 1.0 kg	/ 2
	Recorded Frequency - 1.0 kg	/ 1
	Computed Frequency - ??? kg	/ 2
	Recorded Frequency - ??? Kg	/ 1
	Computed Frequency - ??? Kg	/ 2
	Recorded Frequency - ??? Kg	/ 1
Mission 2: F_3 Note	Mass	/ 2
	Tension	/ 1
Extra Credit:	Smoke on the Water	+ 1
Question 1: Second &Third Harmonic		/ 2
Question 2: Percent Error Calculation		/ 2
Question 3: Source of Error		/ 2
Work Not Shown Fee:		-1 -2 -3
Late Lab Fee:		-4
Total:		/ 20

Equipment:

1. Build an experimental setup like the one at the front of the room. Push two tables close together to put the setup on.
2. For any students with a smartphone, download a free chromatic tuning application. All it has to do is output frequency data.

Mission 1. Data Table

Make a data table for the following tasks:

1. Measure the length of your vibrating string and record it in your table.
2. Compute and record the frequency that a 1.050 kg mass would produce in your system (hanger plus 1.0 kg mass). Use a linear mass density for the string of 6.7 E -4 kg/m.
   Note: you have to calculate the force of tension that the hanging mass exerts on the string by multiplying the total mass by 9.81 m/s^2 (F = ma).
3. Pluck the string and record its frequency in the table.
4. Repeat this procedure for any other two masses. **Do not exceed 5.0 kg!!**

Mission 2. F_3 Note (NOT third harmonic).

Showing all your work, compute exactly how much mass (kg) is required to play an F_3 note (174.6 Hz), and the resulting tension (N) in the string.

Extra Credit: + 1 Point

Play a recognizable rendition of Deep Purple's "Smoke on the Water" on the garbage can base.

Questions: Rephrase and answer in complete sentences for full credit.

1. Choose one of your frequencies and calculate the second and third harmonic frequencies. Indicate which frequency you're using, and show your work.

2. Calculate the percent error between calculated frequency and measured frequency for all three masses in part 1. Show your work for full credit.

$$\%\ \text{Error} = \frac{|\text{Calculated Value} - \text{Measured Value}|}{\text{Calculated Value}} \times 100\%$$

3. Analyze the the previous question. What were sources of error in your experiment? Write in complete sentences as you describe what errors you had, and how they could be eliminated.

AP Physics 1	Unit 12.2 Lab - Tube Acoustics
Reminder: Update Table of Contents	Correction Credit: Half

Insert 12.2 Lab here.

AP Physics 1	Unit 12 - Sound				
Application Problems, AP Test Preparation Questions					
Presentation Points:	/ 5	Late Fee:	-2	Completion (Booklet Check)	/ 5

Your grade on this problem set depends on the presentation you provide for your assigned problems, and whether **all** problems are complete when you submit your Booklet at the end of the Unit.

Application Problems

1. The frequency of a simple harmonic oscillator is doubled from 0.25 Hz to 0.50 Hz. What is the change of its period?

2. A sound wave has a speed of 335 m/s in air. If this wave produces a tone with a frequency of 950 Hz, what is its wavelength?

3. If the frequency of the fifth harmonic of a vibrating string is 425 Hz, what is the frequency of the second harmonic?

4. A tuning fork vibrates at a frequency of 256 Hz at 0.0 °C. If the temperature rises from 0 °C to 20 °C, what is the change in the wavelength?

5. Two sound sources have intensities of 1.0 E -8 W/m^2 and 1.0 E -5 W/m^2, respectively. Which source has a higher intensity level and how much more is it?

6. While standing near a railroad crossing, you hear a train horn. The frequency emitted by the horn is 400 Hz. If the train is traveling at 90.0 km/h and the air temperature is 25 °C, what is the frequency you hear when the train is approaching, and after it's passed?

7. An open organ pipe and one closed at one end both have lengths of 0.52 m at 20 °C. What is the fundamental frequency of each pipe?

AP Test Questions

1. What is the wavelength of a 5 Hz wave that travels with a speed of 10 m/s?
   a) 0.25 m b) 0.5 m c) 2 m d) 50 m e) 10 m

2. A rope of length 5 m is stretched to a tension of 80 N. If its mass is 1 kg, at what speed would a 10 Hz transverse wave travel down the string?
   a) 2 m/s b) 5 m/s c) 20 m/s d) 200 m/s e) 15 m/s

3. A transverse wave on a long horizontal rope with a wavelength of 8 m travels at 2 m/s. At t = 0, a particular point on the rope has a vertical displacement of +A, where A is the amplitude of the wave. At what time will the vertical displacement of this same point on the rope -A?
   a) t = ¼ s b) t = ½ s c) t = 2 s d) t = 4 s e) t = 5 s

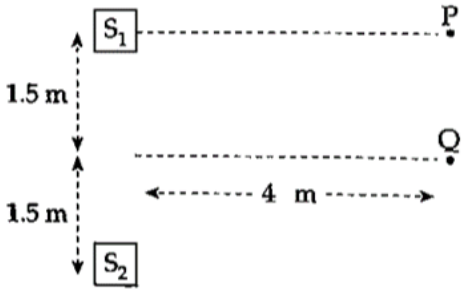
4. A string, fixed at both ends, supports a standing wave with a total of 4 nodes. If the length of the string is 6 m, what is the wavelength of the wave?
   a) 0.67 m b) 1.2 m c) 3 m d) 4 m

5. A string, fixed at both ends, has a length of 6 m and supports a standing wave with a total of 4 nodes. If a transverse wave can travel at 40 m/s down the rope, what is the frequency of this standing wave?
   a) 6.7 Hz b) 10 Hz c) 20 Hz d) 26.7 Hz

6. A sound wave travels through a metal rod with wavelength λ and frequency *f*. Which of the following best describes the wave when it passes into the surrounding air?

	Wavelength	Frequency
(A)	Less than λ	Equal to *f*
(B)	Less than λ	Less than *f*
(C)	Greater than λ	Equal to *f*
(D)	Greater than λ	Less than *f*

7. In the figure below, two speakers, S_1 and S_2, emit sound waves of wavelength 2 m, in phase with each other. Let A_P be the amplitude of the resulting wave at Point P, and A_Q the amplitude of the resultant wave at Point Q. How does A_P compare to A_Q?



a) $A_P < A_Q$ b) $A_P = A_Q$ c) $A_P > A_Q$
d) $A_P < 0$, $A_Q > 0$

8. An observer is 2 m from a source of sound waves. By how much will the sound level decrease if the observer moves to a distance of 20 m?
a) 2 dB b) 10 dB c) 18 dB d) 20 dB

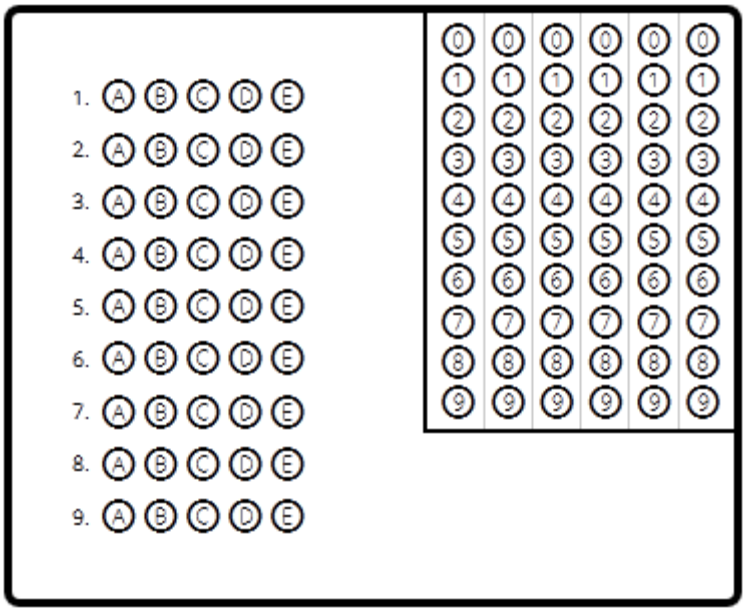
9. An organ pipe that's closed at one end has a length of 17 cm. If the speed of sound through the air inside is 340 m/s, what is the pipe's fundamental frequency?
a) 250 Hz b) 500 Hz c) 1000 Hz d) 1500 Hz

10. A bat emits a 40 kHz "chirp" with a wavelength of 8.75 mm toward a tree and receives and echo 0.4 s later. How far is the bat from the tree if it's 23 °C?
a) 35 m b) 70 m c) 105 m d) 140 m

11. A car is traveling at 20 m/s away from a stationary observer. If the car's horn emits a frequency of 600 Hz, what frequency will the observer hear? (Use v = 340 m/s for the speed of sound.)
a) (34/36)(600 Hz) b) (34/32)(600 Hz) c) (36/34)(600 Hz)
d) (32/34)(600 Hz)

AP Physics 1		Unit 12 Review - Mechanical Waves & Sound					
Points:	/ 18	Late or Incomplete Fee:	-2 -4 -6	Correction Credit:		Final Score:	

Solve these problems here, THEN enter your responses in the bubble sheet provided.
Each question is worth two points.



1. The speed of sound on a summer day is 350 m/s. What is the air temperature?
A. 22.7 °C B. 31.7 °C C. 28.0 °C
D. 33.7 °C E. 38.0 °C

2. A middle C note (262 Hz) is sounded on a piano to help tune a violin string. When the string is sounded, nine beats are heard in 3.0 s. How much is the violin string off tune?
A. 9.0 Hz B. 3.0 Hz C. 27 Hz
D. 29.1 Hz E. 26.2 Hz

3. A point source emits radiation in all directions at a rate of 7.5 kW. What is the intensity of the radiation 5.0 m from the source?
A. 23.9 W/m^2 B. 1500 W/m^2 C. 300 W/m^2 D. 37.5 W/m^2 E. 150 W/m^2

4. A middle C note (262 Hz) is sounded on a piano to help tune a violin string. When the string is sounded, nine beats are heard in 3.0 s. Should the string be tightened or loosened to sound middle C?
A. Tightened B. Loosened C. Not enough information given

5. On a day with a temperature of 20.0 °C and no wind blowing, the frequency heard by a moving person from a 500-Hz stationary siren is 520 Hz. The person is

A. moving toward B. moving away from C. stationary relative to the siren.

6. On a day with a temperature of 20.0 °C and no wind blowing, the frequency heard by a moving person from a 500-Hz stationary siren is 520 Hz. What is the person's speed?

A. 4.0 m/s B. 8.9 m/s C. 10.3 m/s D. 13.7 m/s E. 15.5 m/s

7. The human ear canal is about 2.5 cm long. It is open at one end and closed at the other. What is the fundamental frequency of the ear canal at 20.0 °C?

A. 2150 Hz B. 3430 Hz C. 2895 Hz D. 4682 Hz E. 2950 Hz

8. If the linear mass density of a 7.2-m length of cable is 0.095 kg/m and it is under a tension of 7.50 N, what is the transverse wave speed in the string?

A. 7.65 m/s B. 8.9 m/s C. 8.4 m/s D. 6.3 m/s E. 9.2 m/s

9. A 0.75-m-long metal rod is dropped vertically onto a floor, causing a vibration to propagate from end to end. When the rod bounces off the floor, it is determined that the impact produces a 4-kHz tone. What is the speed of sound in the rod? Approximate the rod as an open ended pipe.

A. 4000 m/s B. 1000 m/s C. 750 m/s D. 3000 m/s E. 6000 m/s